Division of Agricultural Sciences
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PROPAGATION OF CITRUS

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CALIFORNIA AGRICULTURAL
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CIRCULAR 546

PROPAGATION OF CITRUS

. . . is usually done by commercial nurserymen. Most growers do not want to devote the time, effort, space and skill needed to produce satisfactory nursery stock. This circular explains propagating operations, leaving it to the individual reader to decide whether or not he wishes to do the work himself. The information given here replaces the material contained in Extension Circulars 96 and 475, and in AXT-175.

Four aspects of citrus propagation are discussed here:

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Growing Seedlings From Seed

Many different methods are used in the production of citrus nursery trees. No one set of rules applies to all citrus growing areas. For the beginner, growing citrus nursery stock is complicated and involves risk. Successful growers have worked out for themselves the many problems peculiar to their local conditions. Instructions and suggestions are offered here as a basis on which to proceed.

Choosing the site

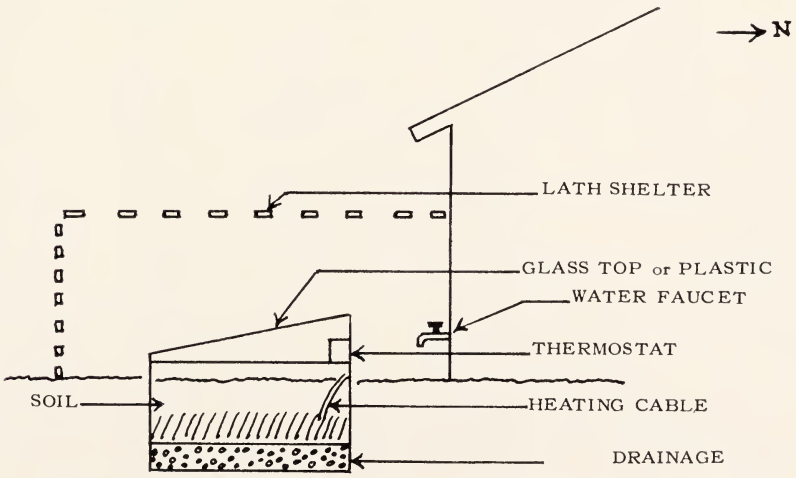
Locate your seedbed where you can inspect it frequently, as citrus seedlings require almost daily attention until they are 4 to 5 inches tall. It helps to have enough room to work the seedbed from all sides. A dependable water supply must be within reach, and some natural protection against cold drying winds is desirable. The site should be fully illuminated, but a certain amount of shading is usually needed until the seedlings are 8 to 12 inches tall. Adjustable shading is better than that which is provided by trees or by permanent structures.

Choose the warmest site possible. Seedbeds placed on the south side of a building receive additional warmth in winter. Provide a conveniently located electric outlet for electrically heated hotbeds.

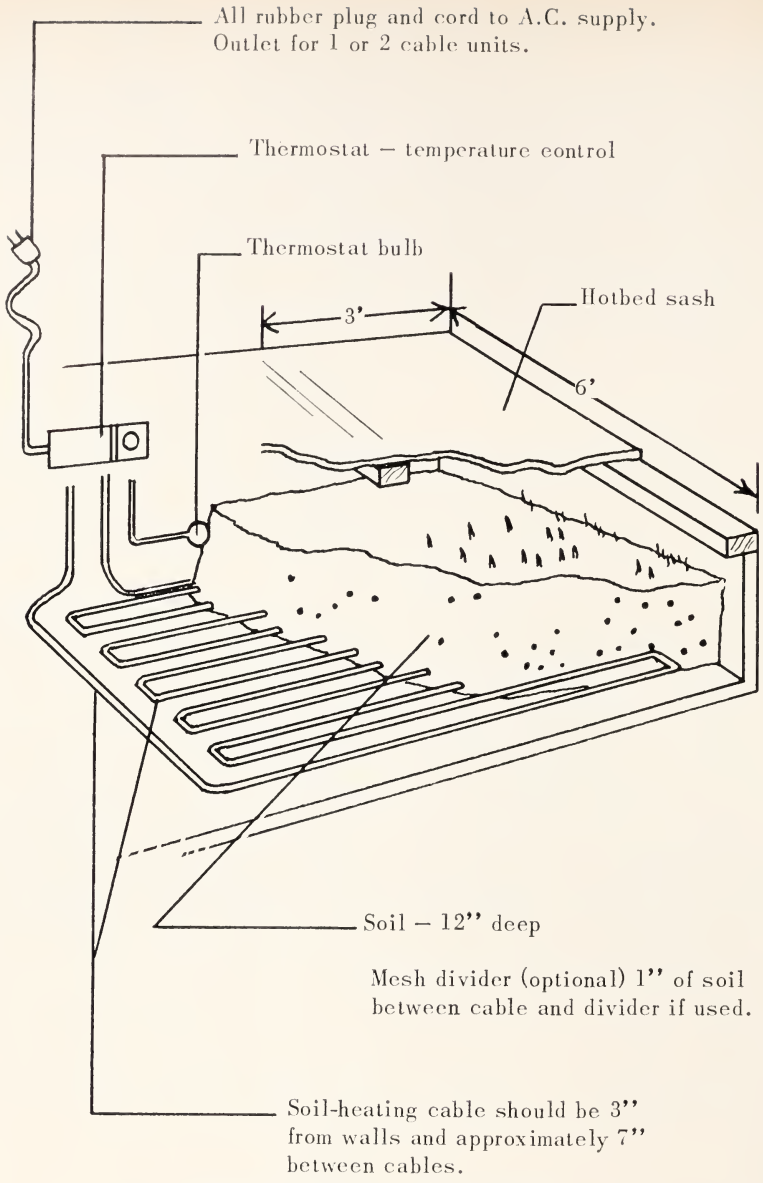
Seedbed soil

Fertile, loamy soil, free from rocks and not recently fertilized with organic matter is preferred for the seedbed. Sandy soil needs more frequent watering and fertilization. Clay soils often remain wet and prevent development of fibrous roots. Clay soils may be made more friable by adding sand and peat moss or Krillium®. It is usually more satisfactory to use medium-textured soil, even if it has to be hauled in.

To promote better root growth, thoroughly incorporate about one-fourth by volume of peat moss in the seedbed soil. Some growers use redwood or pine shavings or shredded fir bark. When these materials are used, it is necessary to add nitrogenous fertilizer at the rate of about 1 pound of nitrogen to 200 cubic feet of material. Damping-off and root troubles increase in soils containing manure, blood meal, and decaying plant remains.



Electrically heated hotbed. The heating cable goes down to drainage area.



Details of electrically heated hotbed.

Use virgin soils whenever possible—old citrus soils contain compounds and organisms that inhibit citrus seedling root activity, and frequently they contain citrus nematodes. If these soils must be used, apply a suitable soil fumigant. (Ask your Farm Advisor about "Annual Treatment Guide for California Citrus Crops," which discusses available soil preplant treatments.) *Allow sufficient time for the fumigant to leave the soil before planting.* Complete pasteurization with steam also provides insurance against soil-borne diseases and nematodes.

Treated soils may require addition of phosphorus, and seedlings may need a spray containing zinc and copper.

Seedlings grown for sale or as rootstock for future budling sale should be grown on soil fumigated under direction of your local agricultural commissioner.

Caution: Do not use methyl bromide on clay soils.

Seedbed preparation

Provide good drainage. In deep, well-drained, permeable soils make certain that soil is properly prepared for uniform irrigation. Where beds are dug in hardpan soil, either break through the hard layer or dig deep enough to insure movement of free water and back-fill with soil of the same texture you use for the seedling roots.

If you add peat moss to the soil, work it in thoroughly. This will be easier to do if you soak the peat moss and allow it to drain a day or so before using.

Many nurserymen prefer to build raised beds by framing the above ground portion with rough 1 × 12-inch or 2 × 12-inch redwood boards. A convenient width to work is 5 or 6 feet. Narrower beds require more lumber, and wider beds are more difficult to weed and inspect.

Seedbed shelters

As the seedlings emerge they probably will need some sort of shelter to reduce the sun's intensity. A small hotbed may be sufficiently protected by camouflage netting, or by a lath frame a few feet above the plants.

For a large seedbed, a lath house or one-half shade Saran® cloth house is useful. Some nurserymen erect a well-braced frame of 4 × 4-inch redwood posts 8 feet high; they cover the sides and top with lath spaced the width of a lath apart, to give half shade. For convenience the lath

Citrus seedbed. Saran® cloth shades protect seedlings from sun. Sideboards define the beds and help protect seedlings from disease.

is sometimes constructed into movable sections. The lath should lie north and south so that the shade moves over the bed throughout the day. Lath used for the sides of the houses is best placed vertically on the north and south sides, and horizontally on the east and west sides. A 1-inch mesh chicken wire netting at the base of the shelter may be necessary to exclude rodents and other small animals. Where moles are a problem, extend the wire 8 inches below the soil level.

Sources of seed

Take seed fruit from trees known to produce vigorous, healthy, true-to-type progeny. Avoid taking fallen fruit from the ground as the fruit and the seed may be infected by *Phytophthora* fungi. Seed parent trees should be grown 24 or more feet apart to minimize possible virus contamination.

Your Farm Advisor can help you select the most suitable seedling parent trees to provide the best rootstock for the kind of soil and buds you wish to use.

Extracting seed

The usual method of extracting the seed is to make a cut around the circumference of the fruit, using care to avoid injuring the seed. Twist the fruit apart and squeeze seeds onto a sieve where they can be washed free from the pulp. Mechanical extractors that do not damage the seed are used when large amounts of seed are required.

Number and size of seed vary widely. Fruit from cool, coastal areas usually contains fewer seed than fruit from warmer areas. Individual trees produce variable amounts and sizes of seed. Fruits tend to contain more seed in heavy crop years. The average number of seeds per fruit is likely to be 10 to 15 with Troyer citrange, 15 to 20 with sweet orange and rough lemon, 25 to 40 with trifoliate orange, 40 to 50 with grapefruit and 25 to 30 with *C. macrophylla*.

The approximate number of seeds per quart is as follows:

Sweet and sour orange	2,200 to 2,800
Troyer citrange	2,400 to 2,600
Trifoliate orange	2,000 to 3,000
Grapefruit	2,200 to 2,500
Cleopatra mandarin	5,000 to 6,000
Alemow (*C. macrophylla*)	4,500 to 5,500

Storing seed

Citrus seeds are injured by drying, so leave them in the fruit until ready for use. If they cannot be planted at once, hold them in cold water for a few days—*if you change the water daily*. When seed must be held longer, store at 40° to 45°F. Trifoliate orange seed stored at these temperatures for 3 to 4 weeks germinate more uniformly. Examine the seed occasionally to make sure it doesn't mold.

To prepare seed for cold storage, remove surface moisture by spreading it on a cloth or fine mesh screen in a shady place until dry. An electric fan hastens drying. When the surfaces are dry, place the seed in polyethlyene (plastic) bags to prevent further drying. Dust the bagged seed with 1 tablespoon of Fermate® or Arasan® per quart of seed to prevent damping off and reduce albinism.

Hot-water treatment

In spite of precautions taken to obtain clean seeds from sound fruit, some seeds could be infested with brown rot fungi (*Phytophthora* spp.). Infected seeds do not germinate, but may infect the nursery soil and cause serious loss of seedlings. Even though seedling shows no signs of infection they may carry organisms with them when they are transplanted to the nursery row and, later, to the orchard. Infected trees often turn yellow and grow weakly, or they may fail to grow.

To prevent infection from diseased seeds, treat the seed with hot water prior to storage and chemical treatment. If done properly the hot-water bath improves seed germination.

The hot-water treatment consists of immersing seeds in water maintained at

120°F for 10 minutes. The bath should be well-agitated to insure uniform heat to seeds. If the temperature goes to 130°F, reduce the holding time to 5 minutes at this figure.

Test for viability

To avoid planting seed that may not be viable, you may apply a chemical test to a representative sample of the seed. The chemical 2, 3, 5-triphenyltetrazolium chloride (T.T.C.) causes living seed tissue to turn red. It has no color reaction with dead seed.

Preparation of seedbed soil

Make the seedbed firm and level to prevent erosion and irrigation run-off. Harrow or rake the surface into a fine tilth. Ready the seedbed so the planting operation can proceed quickly to avoid loss through drying.

To help prevent damping-off caused by the *Rhizoctonia* spp. fungi sprinkle the soil with a solution of special semesan. Three ounces in 17 gallons are enough for 1,000 square feet. After drying to a depth of 2 or 3 inches, acidify the surface soil by applying 1¼ ounces of aluminum sulfate per square foot and evenly rake the chemical into the upper inch. The acidification retards growth of the damping-off fungi without injury to the seedlings—provided the chemical is applied as directed.

Planting seed

Soil temperature of unheated seedbeds should be at least 55°F before planting. Heated beds are usually held at about 80°F. In California, earliest unheated seedbeds are usually planted in March. (Trifoliate and Troyer seed may be planted in February without danger of rotting.) Electrically heated beds may be planted whenever seed is available.

To evenly space seeds, make shallow furrows 1½ to 3 inches apart by lightly pressing the edge of a lath into the soil to make a furrow about ¼ inch deep. Place the seeds about 1 inch apart, and lightly cover them with ½ to ¾ inch of coarse builders sand. (If you suspect the sand carries nematodes or fungi, you can destroy these organisms by fumigating the sand at the same time you treat the seedbed soil.) Sphagnum moss can be used in place of sand. Covering the seed with sand or sphagnum moss aids in the control of damping-off and prevents soil from baking.

Citrus seeds germinate slowly; under most conditions they require about 30 days to emerge, although bottom heat may cut down the time by a third. Soil temperatures of 80° to 85°F are optimum for root growth.

Irrigating the seedbed

Satisfactory seedling growth depends on proper irrigation. Until the seedlings emerge you may have to sprinkle the bed every 1 to 3 days. After they become well established every 7 to 10 days in warm weather may be frequent enough. A tensiometer inserted in the root zone will help you decide when to apply moisture.

After most of the seedlings are germinated and the bed takes on a good green color, you may utilize an overhead sprinkling system. Where flooding is practicable this system may also be successfully employed. The important thing is to irrigate evenly and often enough to obtain maximum growth. Never allow the bed to become soggy or dry and baked.

Fertilizing seedlings

It is easier to grow citrus seedlings in naturally fertile soil than in soil deficient in plant food. Fertilization with organic materials may predispose small seedlings to root rot and to damping-off. If fertilizer is needed use a chemical nitrogen carrier such as ammonium sulfate, calcium nitrate or ammonium nitrate. Dissolve fertilizer in water at the rate of 1 teaspoon per gallon and distribute it over the beds with a sprinkling can at a rate not exceeding 1 gallon per square yard. This provides about 1 pound to 150 square feet.

The solution may burn some of the leaves if it is allowed to dry; a light sprinkling with tap water removes the chemical before it causes injury. Do not repeat more often than necessary to insure normal growth.

Diseases of citrus seedlings

Disease prevention is more satisfactory than attempting to control organisms after they infect the plants. If you use properly treated seed planted in suitable soil and irrigated as indicated, you are not likely to experience serious seedbed losses due to fungus disorders. In addition to the aluminum sulfate treatment you may wish to prevent spread of damping-off by sprinkling the seedbed with Fermate® every other irrigation at the rate of 2 tablespoonfuls per gallon of water.

Rhizoctonia and certain *Phytophthora* fungi grow best under warm moist conditions. Thickly planted seed and poorly ventilated hotbeds predispose seedlings to infection from these pathogens.

Pest control

The most common pests of citrus seedlings are citrus red mite (red spider), citrus bud mite, citrus thrips, aphis and various leaf eating worms. Occasionally grasshoppers or false chinch bugs invade the seedbed. (See "Annual Treatment Guide for California Citrus Crops" for control of these and other insect pests.) Frequent seedbed inspection is necessary in order to detect and treat insect and mite infestation before they grow to damaging proportions.

Culling the seedbed

Cull the seedbed to eliminate weak, off-type and diseased seedlings. A single seed often produces more than one seedling. One of them may grow from a sexually produced embryo that develops as a result of pollination. These seedlings differ from their parents and are frequently too weak to become satisfactory rootstocks. They should be discarded. Some seedlings may be much more vigorous than the average. These, too, should be discarded as they are likely to be sexually produced and, therefore, different from the seed parent. Severe culling now will reduce problems and expense later on.

Other seedlings arise like buds from cells surrounding the sack containing the sexual embryo. This part of the seed is known as the nucellus, and the seedlings which grow from it are called nucellar seedlings. Because this tissue is derived directly from the seed parent, seedlings growing from it are like the seed parent: they are uniform and, if the parent has been properly selected, make good rootstocks.

In some kinds of citrus seedlings the sexual embryo fails to develop, and all or nearly all grow from nucellar embryo and are like the seed parent. Seedlings of Alemow (*C. macrophylla*) rough lemon, Sampson tangelo, and Troyer citrange are usually like their seed parents. Seedlings of sour orange, sweet orange, trifoliate orange and grapfruit produce less nucellars (more zygotics) and require more culling.

Citrus seedlings also differ in vigor and habit of growth. Alemow, rough lemon and Troyer citrange seedlings grow rapidly and produce uniform, upright plants which handle easily in the nursery. Most trifoliate orange seedlings are more thorny and less vigorous. Sour orange and Cleopatra mandarin seedlings grow slower and tend to bush somewhat, but are easily directed toward upright growth. Sweet orange and grapefruit seedlings bush more than the previously mentioned rootstocks. Sampson tangelo starts slowly and tends to be bushy.

Digging, selecting and handling seedlings

Citrus seedlings are ready to transplant when they are 8 to 12 inches high. Well-grown seedlings reach this size 6 to 12 months after the seed is planted.

Before digging, thoroughly wet the soil to a depth of 18 inches; dig when dry

enough to handle. A long-tined spading fork or straight spading shovel is less likely to injure the trees during digging. Gently shake off excess soil and remove at once to a cool, shady, damp place.

Discard all seedlings with diseased, crooked or deformed roots. You will save yourself a lot of time, expense and grief if you use special care to plant or sell only the best stock available.

For convenience in handling and planting, sort seedlings into three or four uniform sizes. Tie or wrap them in bundles of 50 to 100, and plant as soon as possible after digging.

Keep roots covered at all times; never expose them to the sun, nor allow them to become dry. Do not keep seedlings in water after they are dug, as this frequently causes them to die after planting.

If seedlings are to be shipped or stored, pack their roots in moist sphagnum or peat moss. They may be held in ventilated boxes or wrapped in wet burlap.

Citrus seedlings. The two on left are excellent; middle two are acceptable; two on right are not suitable for planting.

Growing Nursery Trees

Growing citrus trees in your own nursery may save you some of the expense involved in setting out a new orchard or in an extensive replanting program. Well-grown citrus nursery stock requires knowledge, much labor, and some capital. Go into such a venture only if you can budget your time so that young trees receive regular attention.

Why grow trees in a nursery?

Growing trees in a nursery as compared with planting seedlings directly in the orchard provides the following advantages:

- You can care for the seedlings and budded trees more easily and more satisfactorily.
- You can eliminate weaker trees.
- Loss of a tree in the nursery is less serious than in the orchard.
- Except for digging cost, growing trees in the nursery is less expensive.

Selection of soil

Medium-textured, well-drained soils free from injurious salts and rocks are most desirable. Clay soils are difficult to ball and hard to work. Sandy soils require frequent irrigation and fertilization.

Soil with no crop history, dry-farmed grain land, or land farmed to crops other than citrus is not likely to be contaminated with organisms harmful to citrus and should be used if available. If you must use old citrus soil or soils containing citrus nematodes, fumigate the nursery site well ahead of planting. (See "Annual Treatment Guide for California Citrus Crops" for fumigation recommendations.)

On recently leveled soil apply one or two irrigations before planting. This will settle the soil and permit releveling when necessary. Problem spots may require special care and fertilization. Two or three years of cropping to legumes or hay helps put the soil in excellent tilth.

Water

Satisfactory tree growth depends on an abundant supply of good-quality irrigation water. If you must use soil or water containing excess salts, construct permanent broad-based furrows and plant in the furrow bottom.

Sprinkler irrigated nursery stock requires high-quality water. Somewhat lower-quality water may be used if sprinkling is done at night when the evaporation rate is low.

With nurseries having permanent furrows and provisions for tail water, removal of running water during cold periods may provide satisfactory frost protection.

Choosing the site

If soil and water conditions are satisfactory, select the warmest available spot as the nursery site. Low frost-hazard locations are frequently steep, and you may have to take steps to prevent soil erosion. Planting on the contour, terracing, sod strips or mulching may be necessary.

Suitable access roads facilitate cultural operations and digging and hauling the trees.

Exposed areas may require windbreak protection.

Planting the nursery

When to plant. The best time to plant citrus seedlings is in early spring as soon as danger of frost is past. You may plant trifoliate orange and Troyer citrange seedlings in late fall or winter, but frost hazard to Troyer may delay planting until early spring.

Spacing. Plant in rows far enough apart to permit the use of cultivator tools. In most cases the distance between rows should not exceed 4 feet. Set the seedlings

10 to 12 inches apart in the row. Straight rows and evenly spaced nursery trees are easy to care for. Some nurserymen prefer to plant double rows 12 inches apart with the trees staggered (alternately spaced). The distance between each double row set is 4 to 5 feet. The double row system permits more seedlings to be planted but usually requires more hand weed control.

Nursery rows. Row length is generally determined by soil type and the method of irrigaton. For furrow-irrigated, medium-textured soils, 200 feet is about right.

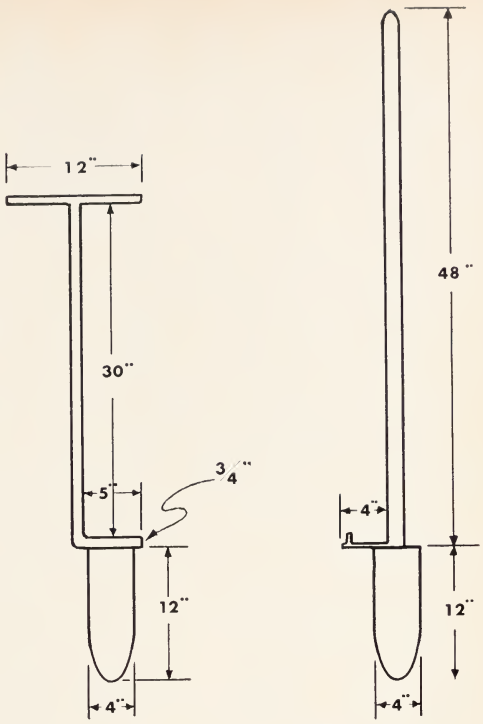
In California it does not matter which direction the rows run in relation to sunlight. However, if strong prevailing winds blow from one direction you will find it easier to train bud shoots if rows run in the direction of the wind.

Nursery heating and spraying is easier if drive lanes about 20 feet apart are provided. By leaving out one or two rows at this interval, you may provide good access for frost protection and for pest-control operations.

Planting operation. Work the soil to a good tilth and firm it. To obtain straight rows, stretch a wire tightly over the ground and walk on it to press it in. The soil must be moist enough to make a good planting hole with a dibble. Thrust the dibble into the soil along the mark made by the wire. Set the seedlings the same depth they grew in the nursery.

To avoid air pockets made by the dibble, use this tool to firm the soil about the roots. Thrust the dibble into the ground at an angle with the point about 3 to 4 inches away from the tree and parallel to the planting hole. When the dibble bar is straightened perpendicularly, it firms the soil about the roots and prevents them from drying out.

Make the dibble hole large enough to accommodate all the roots. If the roots are bent or curled you will probably produce a poor tree. Tap roots must be positioned to grow downward. If roots are too long and limber chop them off with a sharp ax or pruning shears. Always balance root pruning by removing the proportionate amount of the top.



Two types of dibbles used to make holes for seedlings, and to firm soil around roots after planting.

A thorough irrigation helps settle the soil about the roots and provides the seedlings with needed moisture for growth. If the transplants are planted in the furrow bottom, settling by irrigation helps provide good contact with soil and water.

Cultivation

If cultivation is necessary for weed control, work the soil as shallowly as possible. Do not allow weeds to grow in the nursery row; they compete with the seedlings and are hard to control without damage to the trees after they become large. A weed cover in the winter increases frost hazard.

Some nurserymen use weed-killing sprays instead of tilling the soil. To protect trees against herbicide drift, shield them against the spray.

Home-made sled. Shields protect nursery trees from weed-oil spray.

If soil sterilants are applied, use with extreme caution. Most soil sterilants, used at the rates which orchard trees will tolerate, damage newly planted seedlings.

Use of herbicidal sprays replaces frequent cultivation and eliminates the need for special cultivating tools.

Irrigation

Nursery tree irrigation is the most important cultural operation. Overirrigated trees grow poorly and turn yellow. Lack

of water stunts growth and causes buds to die before they unite with the stock. Trees that are too wet or too dry are more subject to frost damage than are properly watered trees.

Furrow irrigation is usually satisfactory and is a must if the water contains injurious salts.

Sprinkler irrigation may be used where erosion is a problem. Mite infestations may be reduced when the nursery is sprinkled. On the other hand, loss of desirable insecticide residues may reduce pest-control effectiveness.

Fertilization

Fertile well-drained soils help grow good nursery trees. To maintain adequate soil fertility, chemical nitrogen is usually necessary. A light application of ammonium nitrate, calcium nitrate, ammonium sulfate or urea spread down the tree row at the rate of 1 pound of fertilizer to every 100 feet is sufficient. Apply as often as necessary to maintain satisfactory growth. Wet the soil thoroughly after fertilizing.

At the first indication of mottle leaf, treat trees with zinc oxide at the rate of 1½ pounds per 100 gallons of spray. This material may be combined with insecticides needed for pest control.

Time for budding

Small seedlings lined out in the spring normally require a year's growth in the nursery row before budding. The minimum size for budding is determined by the size of the buds and the rootstock. Most nurserymen prefer at least pencil-sized stock because slender seedlings are too limber to handle easily; furthermore, small seedlings do not force the buds to grow vigorously and the bud shoots must be tied frequently. If the stock is large enough because of favorable growing conditions, spring-planted seedlings may be fall budded.

Fall budding is often preferred to spring budding. The time to start fall budding is after the middle of September. Place buds early enough so they will unite with the stalk, but late enough to avoid shoot growth. Spring budding begins as soon as the bark slips easily and may continue until mid-summer. In areas where frost is a problem spring budding should not be later than early May. Trees budded after that time are more subject to cold injury in fall and winter. Whether you bud in the fall or in the spring, you should strive to insert the buds before stock is larger than ½ inch diameter at the point of insertion. If the seedling is larger than this you will find it harder to get a good "take"; the bud union will be more pronounced, and the bud shoot will be more subject to breakage at the union.

Remove suckers beneath the point where you intend to bud as soon as possible after they appear. To prevent suckering and sunburning some nurserymen enclose the seedling trunk with paper, foil, or plastic tubes to an inch or two above the point where the bud will be inserted. Pruning should not be done less than 3 weeks before budding; it causes the bark to tighten and lessens the chances for a good bud take.

Bud as soon as possible after an irrigation. Ample moisture helps insure cambial activity, and the barks slips easier.

The seedling should have a clean, straight trunk at least 6 inches above the soil. There is no excuse for budding lower than 6 inches. Trouble from brown rot gummosis can often be traced to low budding.

Selecting budwood

Use buds from the best producing, true-to-type, disease-free trees for propagation. Where possible, bud each block of nursery trees from a single parent source. This helps to insure more uniform tree behavior in the orchard.

Since bud sports develop rather frequently with all citrus, avoid off-type growth when you select budwood. Cut off sport limbs whenever they appear in budwood "mother" trees.

Be particularly careful when choosing buds for propagation on trifoliate and

trifoliate hybrid rootstocks. Use only nucellar buds, or buds from high-producing trees grown on trifoliate rootstock and preferably indexed for the exocortis virus. Make sure the parent trees meet State requirements for freedom from virus diseases such as exocortis, Psorosis, stubborn, and tristeza. In tristeza-infected areas it is difficult to choose budwood not contaminated with this virus. It is highly desirable to use tristeza-free budwood in all propagation, and it is imperative that it be used when budding tristeza susceptible rootstocks such as Alemow.

Take nucellar buds for propagation directly from the parent nucellar tree or from seedling trees budded to nucellar varieties. *Once you place a nucellar bud on a previously budded stock there is no certainty that progeny from this line will be disease free.*

In choosing budwood you will usually find the best material on the next to the last flush of growth, or the last flush after it matures and hardens. You may also get perfectly good buds several cycles below the last, up to the point where the bark is no longer green. A round budstick will yield more usable buds, but you can use angular wood that has hardened when you cannot find better material. Buds in the axils of large, healthy leaves are best. Small leaves on the budstick signify poor nutrition and these buds usually start growth later than well-nourished buds.

Cutting and storing budwood

You may cut budsticks just prior to budding, or you may cut and store them for several weeks. Most budders store budwood that is not used more than a day or two after it is cut. Do not use dried, moldy, or water-soaked buds.

At the time of cutting, clip off all leaves and cut the sticks into convenient lengths to handle. Never allow buds to dry out. Bundle them as soon as possible and label them as to date, name, source and registration number. Put them in a good storage medium or polyethylene bag, and store them in boxes or folded clean, damp, burlap sacks in a cool, dark place.

Budwood storage media are damp peat moss, newspaper, coarse sawdust and vermiculite. Wet the material thoroughly before using and allow the free moisture to drain away prior to covering the budsticks.

Budwood stored in sealed polyethylene bags does not need additional moisture nor does it need to be packed in a holding medium. It is held under refrigeration from 40° to 50°F.

Budding

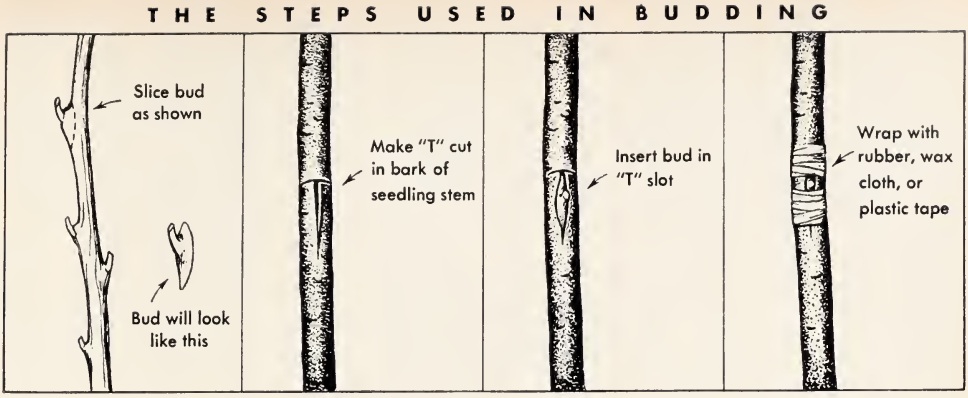
Use the shield or "T" bud method. Properly done, it gives excellent results, with a minimum of effort.

A good sharp knife with a rounded point is used to slice buds from the budsticks. Large buds for insertion into pencil sized and larger stocks should be cut up to an inch long and deep enough to include a sliver of wood. Smaller buds may not include wood.

Here is the procedure: Slice the bud from the stick and hold it between the thumb and knife blade. Make a perpendicular cut on the stem of the seedling. With the blade held at an angle make a second incision horizontally at the upper end of the first cut. This is done to open the bark where you want to insert the bud. Finally, shove the bud into the opening at the junction of the cuts. Be careful to place the bud with the right end up—leaf base down. Wrap bud with plastic tape, rubber strips, or waxed cloth immediately.

In wrapping buds, start above bud and work down to avoid moving the bud out of place. Tie buds firmly but not so tightly as to impede growth. Cover fall buds completely with the wrap. Spring buds should have the eye exposed, because bud shoots may start before the wrap is removed.

Newly budded trees must not be allowed to wilt.



To get uniform trees and facilitate handling, bud all trees in the row at the same time and at the same height (6 to 8 inches above the soil).

Unwrapping and forcing buds

Unwrap fall buds after they are well caloused in—1 to 2 months after budding. (Some kinds of rubber wraps need not be removed; they deteriorate and drop off.)

Spring buds take more quickly than do fall buds. Usually you may remove the wrap after 2 to 3 weeks of good growing conditions.

Force fall buds by lopping or by removing the top 3 to 4 inches above the bud just before spring growth starts. Lop by breaking or partly cutting the stem so that the seedling top lies on the ground.

Budling, showing seedling top bent over to force bud to grow.

Small budlings should be lopped so the top may continue to nourish the root.

Force spring buds by lopping or bending immediately, or a day or two after bud wraps are removed. Buds may fail to start if you delay lopping too long. If some buds fail to shoot within 6 weeks after lopping, bend or shake lops to make sure they are not too strongly attached. Some buds may have to be forced by cutting off the top.

To get the most benefit out of lops leave them on the trees throughout spring and summer. (Usually, however, they are removed after the bud shoots make 28 to 30 inches of growth.) If growth from the bud is weak and the lop is in the way, leave the stub until the following spring. If you remove the stub on weakly growing budlings too early, you may lose the bud and—occasionally—the seedling.

Because unhealed cuts predispose trees to frost damage, do not remove stub after the first of September. If bud shoots are above 30 inches by fall remove the lops then—although no harm results from letting lops or stubs remain until digging time. When you cut the stub off, you may hasten healing of the pruning wound by covering the cut with a good asphalt emulsion preparation.

Staking

To develop straight trunks, citrus bud shoots usually require some support. Many nurserymen use 1 × 1 inch redwood

Tying budlings (grown as canes) to stakes.

stakes, 4 feet long, or sharpened 4-foot laths.

Drive laths about 6 to 8 inches into the ground, about an inch away from the bud shoot and with the narrow side opposite the shoot. This allows the leaves to give some support to the stem and permits the "head" to develop evenly.

Use soft twine, raffia, plastic tape or "twistems" to tie shoots so they will grow into straight trees. The ties must be tight enough to prevent the budlings from whipping in strong winds, but the ties must not pinch the shoot. Use no more ties than necessary. If you keep raffia moist while working, tying is quicker and more satisfactory.

Remove all suckers by rubbing off before they get so big they have to be cut with shears.

Training

For the retail nursery trade and some growers, heading the trees in nursery is necessary. To get the best spacing of branches, allow shoots to grow a foot or

two above the stake and cut them back to the desired height—usually 30 inches. Allow three to five well-placed limbs to develop on the trunks, and remove all other shoots.

Instead of "heading" trees in the nursery, many commercial nurserymen encourage the bud shoots to grow straight up the stake as high as they will in one season. Trees grown this way are usually called "whips" or "canes." This procedure eliminates a certain amount of suckering and usually produces trees of larger diameter. When trees (whips) are cut back to 28 or 30 inches above the ground at the time of digging, it has the effect of balancing top and root. The head is easily developed in the field after transplanting. Whips are much easier to dig and handle than headed trees, especially when extra handling of fumigation and dipping is required. Another advantage is that whips are easier to ball.

Digging the budlings

Balled trees. Most citrus trees are dug with a ball of earth adhering to the roots. This allows more time between digging and planting. Balled trees start growth sooner after being set out in the orchard than do trees handled bare root.

Trees to be balled should be trimmed to the desired height a week or two before balling.

The shape of citrus nursery balls is determined by the distribution of the root system of the trees to be moved. Save enough roots to insure safe transplanting but keep the soil attached at a minimum for easy handling. Balls 7 to 8 inches in diameter and 16 to 18 inches deep are used in most California soil types.

Balling. Use a special balling spade. Have the soil moist but not wet. Thrust the spade all the way straight down 3 to 4 inches from the trunk on all four sides. This cuts all lateral roots and makes a ball about 8 inches in diameter. After the last thrust, leave spade in position and dig soil away from the back of the spade so as to leave a hole for lifting out the ball. Thrust spade down again on the opposite side of the ball, and then with a shovel cut under the ball so as to sever tap root at desired depth. Lift the ball out on the balling spade and place it on a piece of burlap or other suitable wrapping material. If burlap is placed on a light bench, handling will be easier.

Wrapping the ball. To tie the wrap, slip the spade from under the ball and fold the wrap around the ball. Gather the wrap around the trunk of the tree and tie it in place as close to soil surface as possible. Next, make three evenly spaced half hitches around the ball and pass the twine under the ball and up the opposite side to the trunk, where it is tied securely. Have the lowest half hitch near the bottom of the ball to protect the ball from spreading when wet. If the tree must be held for several weeks, use twine that has been treated with a fungicide to resist decay.

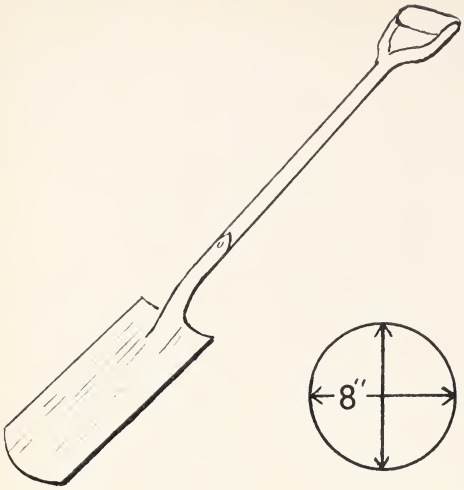
Bare rooting. Bare-root trees must be handled quickly and carefully. Never permit the roots to dry. In interior and desert areas, defoliate and whitewash trees just before digging. In cool and humid coastal regions this may not be necessary.

Advantages of bare rooting: It permits inspection of the root system. It also allows you to retain more of the root system than on balled trees. Two-year-old trees handle better bare-rooted than balled. On very heavy soils, bare rooting is preferred to balling, especially when trees are to be moved to lighter soils.

You can best dig bare-root trees in early spring. You may dig balled trees from the time the ground can be worked after the danger of frost is past until the weather turns hot. Do not dig during dry, windy weather.

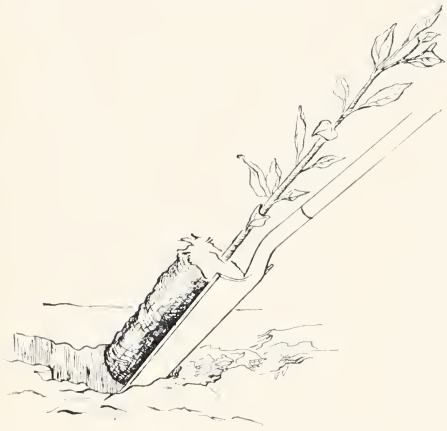
Some fall digging of citrus trees is done every year. However, frost hazard keeps many growers from planting at that time—which limits the demand for fall-dug citrus trees.

STEPS USED IN BALLING

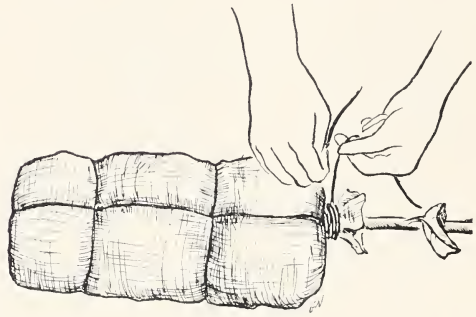


Balling spade 16 inches long. Circle shows diameter of ball.

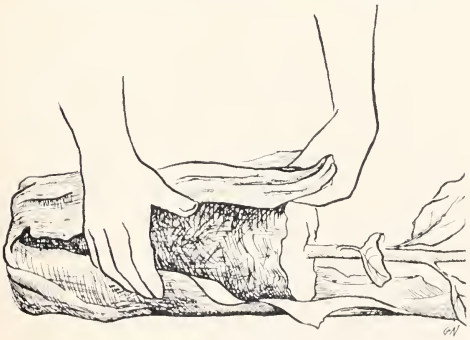
Cutting tap root with shovel.



Lifting ball out of hole on balling spade.



Finished ball.



Wrapping ball with burlap.

In citrus-growing sections along the coast (and during early spring inland also) when the weather is cool and overcast, you may successfully transplant bare-root trees having some leaves remaining. If you doubt that you can keep the trees from wilting, it is best to defoliate at digging time.

Handling dug nursery trees

Bare-root nursery trees must be dug quickly and the roots placed in damp peat moss, mud, or vermiculite until planted. If you do not plant the trees at

once, keep them in a cool, shady place.

You may store balled trees in a shady place for a few days or in a lathhouse for several weeks if necessary. Balled trees may even be held a day or two in the open, provided soil around their roots is not allowed to dry. If they are without shade protection until new growth develops, the trees are liable to sunburn and should be sprayed with whitewash. Do not allow the balls of earth to become hard and dry at any time. If this happens, wet the balls until soaked through. The best way to forestall such accidents is to pack the balls in damp sawdust in bins and sprinkle as frequently as necessary.

Since citrus trees can be stored from a few days up to several weeks, it is best to hold them after digging until there is favorable weather for planting; or to dig and plant the same day under the most advantageous conditions.

Growing Citrus Trees From Stem Cuttings

Citrus trees may also be propagated by rooting stem cuttings. This method is used principally for producing plants which are grown and sold in containers. In years when seeds of a desired rootstock are not available in sufficient quantities, cuttings may be rooted from nursery seedlings of the previous year; these cuttings can then be budded as described for seedlings.

Generally, citrus trees grown from cuttings reach the same size as trees of the same variety budded on one of its own seedlings. Eureka lemons grown from cuttings are weak and have not proved to be long-lived on their own roots.

In their first two or three years, cutting-grown trees are not as well anchored in the soil as are trees budded on seedlings. In extremely windy locations, stake young cuttings to protect them from being blown over.

Another possible trouble with cutting-grown rootstocks in some areas may develop at the time of balling the nursery tree. The root systems in many cases spread more laterally than do those of seedlings, and only a few roots can be included in the standard nursery ball. In these cases the trees should be dug and moved bare-root.

The speed and ease with which cuttings form roots varies with the different species of citrus. Lemons, limes, and citrons root most readily; mandarins are the slowest and most difficult. Grapefruit, sweet orange, trifoliate orange, the citranges, and sour orange are in-between.

Selection of cutting material

Cuttings from young seedlings (young clones) of any species root much more readily than cuttings from old clones of the same species. Roots from old clones tend to be more lateral; those from young clones send roots straighter down; cuttings from extremely young seedlings are almost as tap-rooted as seedlings. The best cutting material is growth that has just matured.

The largest number of recently matured cuttings is available in June or July, having resulted from the spring flush of growth. In areas where there are several flushes a year, you may find good cutting material in any month. Some propagators prefer winter cuttings taken from the

north side of the tree; these root well if the trees have been maintained in good condition throughout fall and winter. Shoots from trees which recently have been oil sprayed do not furnish satisfactory cuttings. The oil increases leaf drop when cuttings are placed in the propagating frames.

Cutting procedure

The best cut is one squarely across the base; it will result in the formation of more roots and give a better root distribution than a slanting cut. The position of the basal cut as related to the buds on the stem is immaterial.

Most satisfactory are terminal cuttings 3 to 6 inches long, with mature leaves and consisting of a single growth flush. Strip leaves from the area near the base so you can place the cutting easily in the rooting medium. Leave three to six leaves on each cutting. Keep cuttings moist during all handling operations after removal from the tree.

Treatment with hormones

Some citrus species benefit by a treatment with rooting hormones. Lemons, limes, citrons, citranges, and trifoliates respond to a treatment of indolebutyric acid (IBA) in talc at from 3.000 to 8,000 ppm. This materal can be obtained as a commercial preparation labeled Hormodin® powder. Number 2 powder contains 3,000 ppm IBA, and number 3 powder 8,000 ppm. To apply material, moisten base of the cutting and dip it into the powder to a depth of about ¼ inch. Be careful that there is no bead of free water at the base of the cutting, as this would prevent powder from adhering to the tissue.

Some of the more difficult materials, such as Satsuma mandarin, may benefit from a quick dip into IBA at 10,000 ppm. To make this solution, dissolve IBA crys-

Propagating frame for stem cuttings.

tals at the rate of 20 mg in 1 cc of alcohol, and add an equal volume of water. Dip the base of the cutting into the solution about ¼ inch deep for one or two seconds.

Rooting and removal of cuttings

Cuttings may be rooted in any structure that maintains high humidity and gives good light intensity. The two main choices are closed propagation beds, or a mist system by which the cuttings are placed under water mist sprays which can be turned on or off. Closed frames are satisfactory, but require more attention than the mist system. Citrus cuttings under mist leach badly if they root slowly. To improve their condition fertilize periodically. Leaching does not occur in the closed frames.

Place the cuttings about 1-inch deep in any well-aerated medium such as vermiculite, sand, or sand and peat. Space them far enough apart so at least a portion of every leaf is exposed to light.

Bottom heat is essential except during the warmest seasons. A minimum temperature of 75°F works well for rooting, and optimum temperature appears to be between 80° and 90°F. In closed frames you can control the air temperature by adding or removing shade. Never allow the leaves of the cuttings to wilt. Syringe the foliage and the inside of the frame daily in normal weather, and more often during periods of extreme high temperature. Give the cuttings as much light as possible, but hold air temperatures inside the frames below 100°F to prevent burning of foliage.

Lemon cuttings produce good roots within 4 to 6 weeks; oranges, citranges and trifoliate orange in 6 to 8 weeks; mandarins will take up to 4 months or more. These periods will vary with the weather and condition of the cuttings.

After the cuttings are rooted they are hardened off by gradually reducing humidity in the frames. If the mist system is used, harden cuttings by gradually decreasing the "on" period and increasing the "off" period.

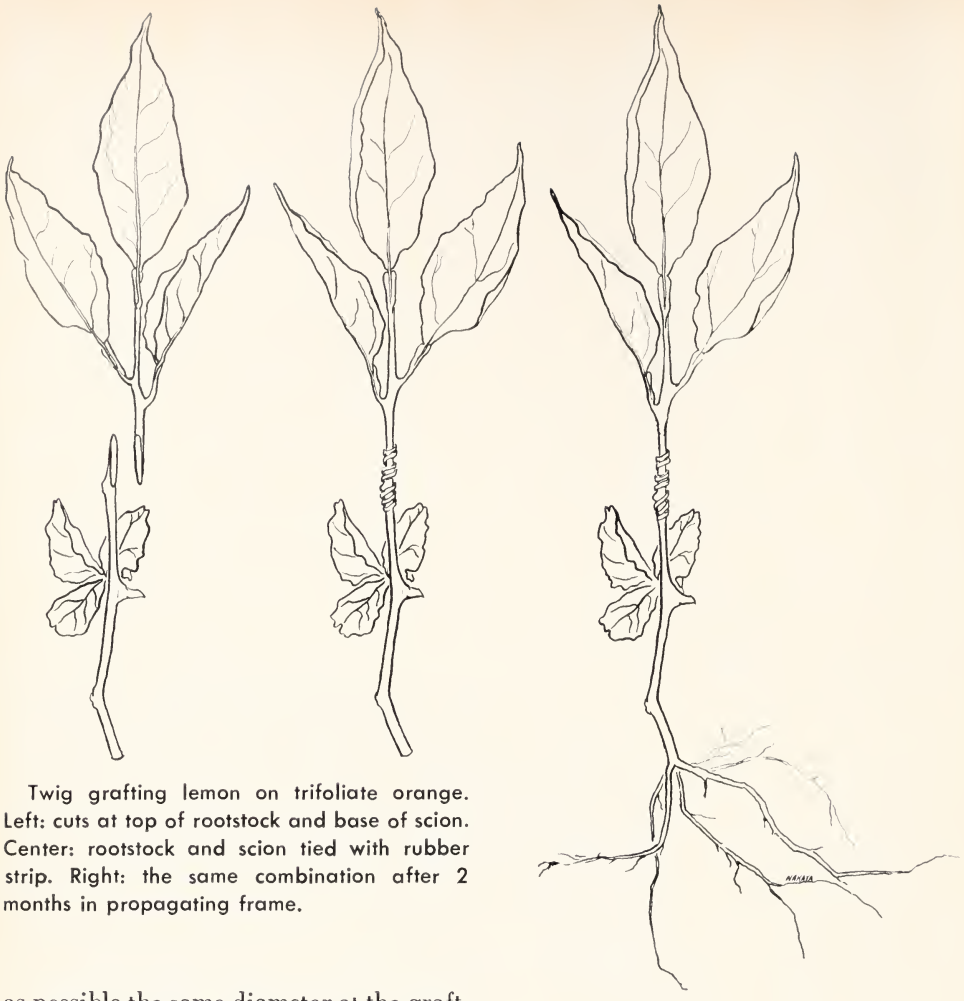
Remove cuttings and plant them in containers or in a nursery row. In hot or dry weather protect them from direct noonday sun—a shingle placed on the south side of the cutting works well in the nursery row.

Twig grafting

Twig grafting, a method sometimes used in cutting work, employs two or three cuttings grafted together. Two cuttings gives a desired rootstock-scion combination; three cuttings a combination of rootstock, scion, and interstem. For twig grafting use the same type of material as described above for cuttings.

Select material that will have as nearly

Rooted cutting ready for transplanting.



Twig grafting lemon on trifoliate orange. Left: cuts at top of rootstock and base of scion. Center: rootstock and scion tied with rubber strip. Right: the same combination after 2 months in propagating frame.

as possible the same diameter at the graft. Keep at least three leaves on the top or scion piece, at least one leaf on the lower or stock piece, and one leaf on the interstem if used. Make a sloping cut ½ to ¾ inch long at the base of the scion piece and at the upper end of the rootstock piece. Hold the two pieces together with thumb and forefinger of one hand so that the sloping cuts cover each other. Then wrap the union with raffia or a rubber strip by making several turns as shown just above (a number 16 or 18 stationer's rubber band which has been cut makes a good wrapping material). To start the wrapping, hold one end of the strip between middle finger and forefinger of the hand holding the cuttings.

Some experience is necessary to judge the tension of the tie: if too loose, the pieces may spread apart or shift; if too tight, the bark will be damaged. You need not seal the cut surfaces, as the high humidity will protect them from drying. Unions at the graft should heal in 3 to 4 weeks, at which time the tie can be loosened or removed. How long it takes to root these combinations depends on the piece at the base. Materials rooting readily as cuttings also root readily as the basal portion of the grafted plant; those that are slow as cuttings are also slow as the rootstock of the graft. Remove cuttings when root length totals 6 to 8 inches.

Topworking Citrus Trees

Citrus growers sometimes wish to change established groves to other varieties. It is often cheaper to graft existing trees to another variety than to pull out the stumps and plant new trees. Topworked trees will also come back into production sooner than nursery trees. Trees to be topworked must be thrifty and free of fungus or virus diseases that would affect the new top. If you are in doubt whether your trees are suitable for topworking, call in your Farm Advisor or another competent person.

Topworking of citrus trees can be done by budding or grafting. Either method may be used on any size of trees, but in most areas younger trees are budded while large trees are grafted. In some areas, particularly Central California, budding is preferred for trees of all ages.

Topworking by budding

Budding can be done in two ways: either directly into the trunk or scaffold limbs, or into new shoots of heavily cut-back trees. The last method gives a good percentage of bud take, but some time is lost in growing the shoots; also, more follow-up work is required. Most budding is done directly in the scaffold limbs.

Select the branches in which you will place buds and remove all growth which is in the way. Usually some unbudded branches are left as "nurse" limbs.

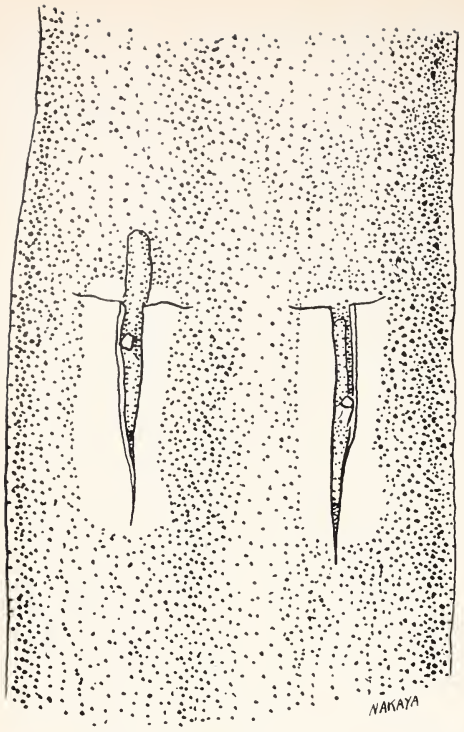
You may bud in the fall, or, more generally, the following spring when the bark slips well. Start spring buds 3 to 4 weeks after budding by cutting back the branches or by girdling (removing a strip of bark ¼ inch or more wide completely around the branch) 2 to 3 inches above the bud. Buds placed in the fall are held dormant by not cutting back or girdling the branches until the next spring. Be careful to avoid splitting when cutting off large branches: remove most of the weight of the branch with a first cut farther out on the limb, and then make a second cut closer to the bud.

Budwood for topworking should be larger than that described in the section on budding nursery trees. On large limbs, two buds are often placed at the same height so that they can be tied with one wrapping operation. Make a T-cut in the limb where the bud is to be placed, and lift the bark to insert the bud. If the bark is too thick to manipulate well, scrape it with a knife to thin it to about ⅛ inch.

Select budsticks about ¼ inch in diameter. Cut the bud from the budstick and insert it in the bark incision as described (pages 14–15). Be careful not to place buds in an inverted position. For topworking make the shield (bark and a thin layer of wood attached to the bud) about 1½ to 2 inches long. With a shorter shield there is the danger of bark growing over it and smothering the buds. After buds are inserted, tie them in by wrapping over them with waxed budding cloth or plastic tape.

After 3 or 4 weeks remove wraps and examine buds to see if they have remained alive. If callus tissue has grown over the bud cut the tissue away carefully—otherwise the bud may become buried and will fail to start. If the buds look all right, shorten or girdle the branches; this should start the buds growing.

After the new shoots have made good growth, cut the branches off flush with the bud and seal the cut surface with a pruning compound. Make this last cut at an angle; this gives better healing on vertical branches, and prevents water standing on the wound surface. All nurse branches should be removed so that all the growth goes into the new top.



Topworking by budding. Left: bud partially inserted. Right: bud inserted and ready for wrapping.

Topworking by grafting

Grafting of old citrus trees is done with the bark graft. Dehorn trees and set the scions in the main scaffold limbs, or cut off these trees below the branches and set the scions in the main trunk. When grafting into the scaffold branches leave some branches on as nurse limbs, both for shade and to maintain the root system until new scions develop foliage.

Graft when the rootstock bark separates readily from the wood. About a day after cutting a tree back the bark tightens; thus, if the grafting is not done immediately after cutting wait about a month until the bark loosens again, at which time re-cut and graft the limb stubs or stump.

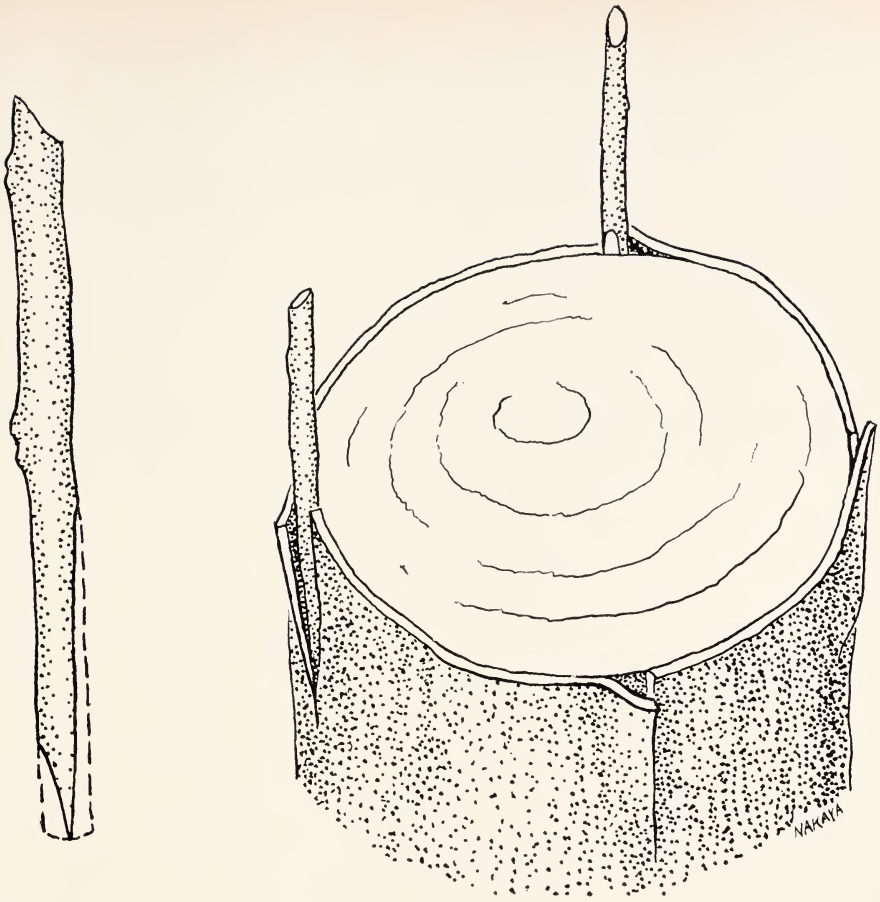
Here are the directions for a bark grafting method which has proved satisfactory: cut off the branches and make vertical slits (2½ to 3½ inches long) in the bark of the stub where the scions are to be placed. These cuts extend through the bark to the wood and are from 3 to 5 inches apart around the stub. Select scion-wood from firm, current season's growth, or from wood as old as two or three years. the diameter may vary from $\frac{3}{16}$ to $\frac{3}{8}$ inches.

Cut a scion (see page 25) with a long sloping basal cut 2½ to 3 inches long. Sometimes a second sloping cut ½ inch long is made on the opposite side. Leave at least two good buds above the longer cut. Lift bark on one side of the cut on the stump high enough to insert the scion, and push down scion with the long cut facing in toward the wood—one side of the scion should fit snugly against the unlifted portion of the bark on the stump. A little cut surface on the face of the scion should still be visible above the rim of the stump after the scions are inserted.

Don't make scions longer than necessary, as long scions can dry out before unions can form. The scions may be nailed in place with thin flat-headed nails, or tied with several loops of cord, friction tape, or vinyl tape around the stump. On some very large stumps baling wire has been used successfully. Take care to have a good fit and enough pressure to hold the scions securely at the point where the top edge of the stump and the cut surface of the scions join; most of the strength of the new union will be in this area. After the scions are fastened, seal all cut surfaces with a pruning or grafting compound to prevent drying.

Protection after grafting

After grafting, protect the scions and trunk from burn resulting from direct sunshine on exposed surfaces. Whitewash trunks and branches on the south side and shade the scions with ventilated paper bags or other material to keep direct sunlight from striking them. Scions may also be protected from the sun by covering



Topworking by bark grafting. Left: scion, showing two cuts. Right: stock, showing vertical slits in bark and two scions inserted.

with white latex paint. As the scions start to grow, tear the bags to let the shoots come through into the sunlight.

Keep an eye on the material you used at grafting time to tie the scions; loosen or remove the ties before they cut into the bark.

In areas where strong winds may break the scions out as they grow, nail 1×2-inch boards to the stump for support. These boards should extend 3 to 4 feet above the graft. Tie the shoots loosely to them. Many propagators prefer to protect against breakage by merely cutting back or pinching the longer shoots to keep them short and bushy.

Rub off all shoot growth on the stump immediately around the new buds and grafts so they won't compete with the new top. If nurse limbs have been left on the stump, cut them back or remove them before they interfere with the new growth from the scions. Eventually, all shoots below the scions will require removal.

To simplify the information, it is sometimes necessary to use trade names of products or equipment. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

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George B. Alcorn, Director, California Agricultural Extension Service.

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